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Radiation hardness testing for cameras utilized in Mo-99 production facility

Introduction

The IR and visible light cameras foreseen to be used in beam profile monitoring in the Mo-99 production facility were observed to exhibit premature failures during test run at ANL. Since these devices were tested in photon fields up to 2 MeV we believe that the failures were caused by neutron fields generated by photonuclear reactions.

Lujan neutron scattering center is a pulsed neutron source optimized for delivery of thermal and cold neutrons. However sizable amounts of resonance and fast neutrons are present at the experimental flight paths. We submitted a proposal for radiation hardness testing of these cameras at Lujan Center. As the camera body is about 2"x2" we need fairly large beam spot size to ensure uniform exposure of the entire camera hardware enclosure.

Neutron spectra at the production facility

We carried out MCNPX calculations of the neutron energy spectra present at the production facility (see Fig. 1) at 2 meters from the target along the electron beamline. Figure 1 depicts the tally location at the electron beam height. The camera will be placed 2 meters away from the target, but at a lower elevation than the beam axis.

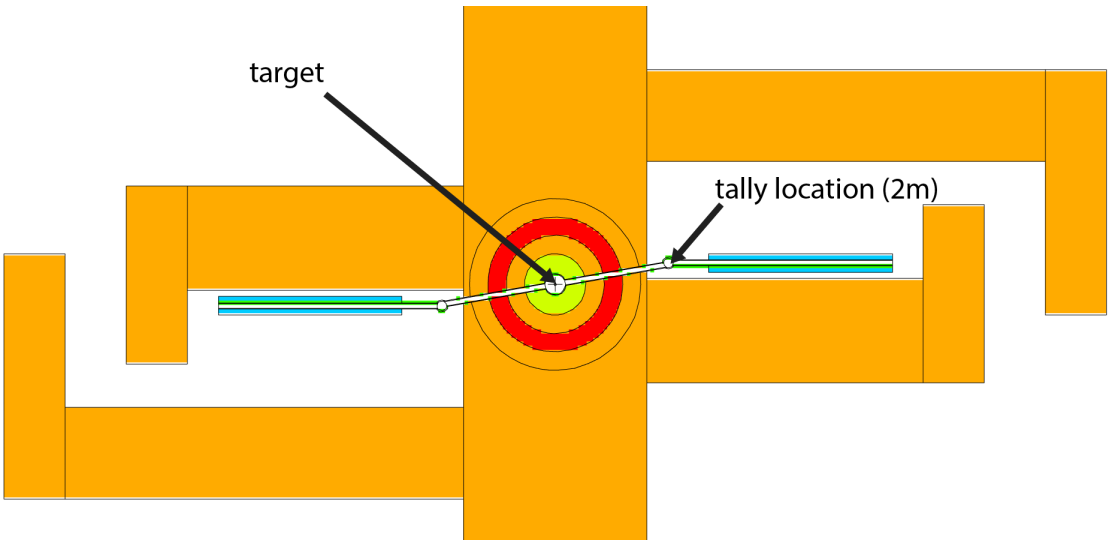

Figure 1: Facility layout section at the axis of both electron beams. The tally location at beam height is clearly depicted.

We placed neutron energy tally 2 meters from the target along the electron beam line at the beam height. Additional tallies were placed below the beam axis at 10, 50, and 100 cm.

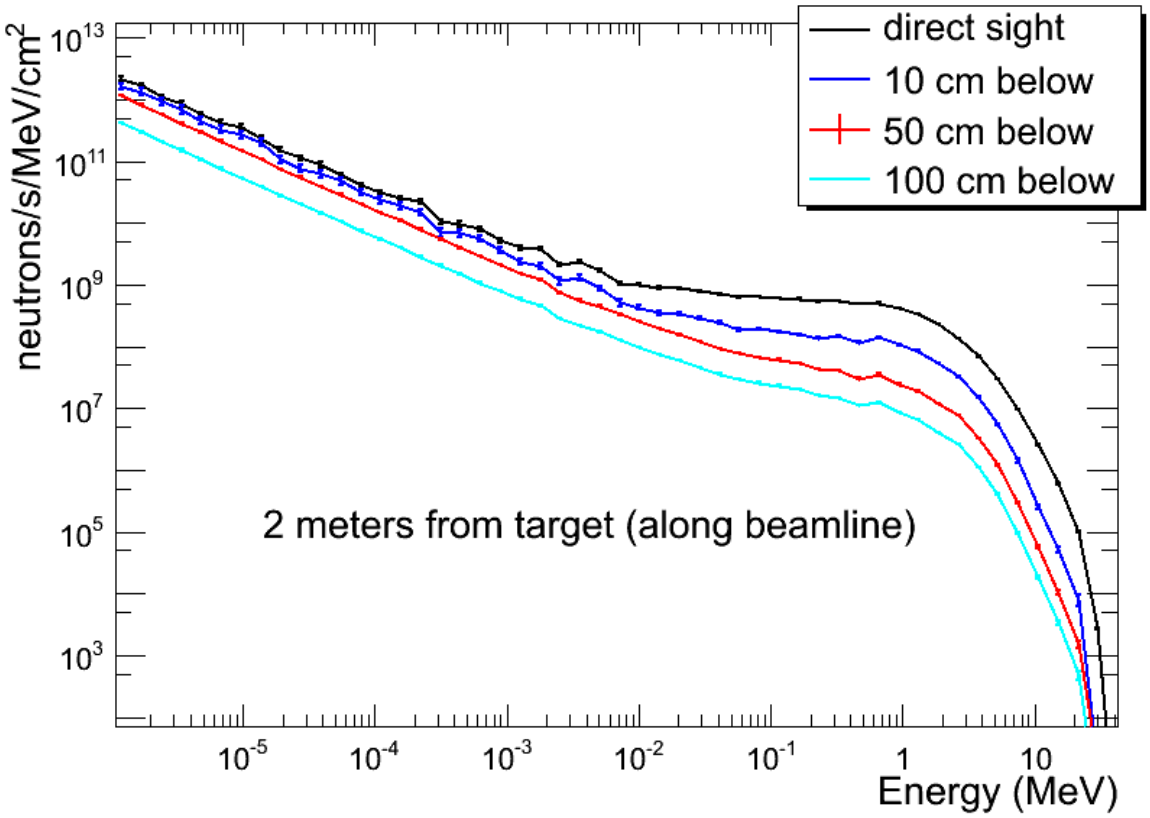

Figure 2: Neutron energy spectra at 2 meters along the beam.

Neutron spectra available at FP-5

FP-5 is a thermal neutron beamline, viewing chilled water moderator. Integrated thermal neutron flux is approximately 10E+06 n/s/cm^2.

The simulated spectrum at FP-5 scaled to the nominal production level at Lujan Center, is compared to the expected neutron energy spectra at the production facility in Figure 3. At the low energy tail the FP-5 spectrum reproduces the expected spectra at the production facility. We note a deficiency of high-energy neutrons in the 1-20 MeV energy range at FP-5.

We carried out further simulations projecting the neutron and gamma spectra at FP-5 when using different filter materials and thicknesses. The spectrum after 2mm thick cadmium filter is compared with the reference neutron spectrum at FP-5 in Figure 4.

Figure 5 presents the neutron energy spectra filtered by lead and bismuth filters of different thicknesses (5 and 10 cm). Gamma spectra at FP-5 are presented in Figure 6.

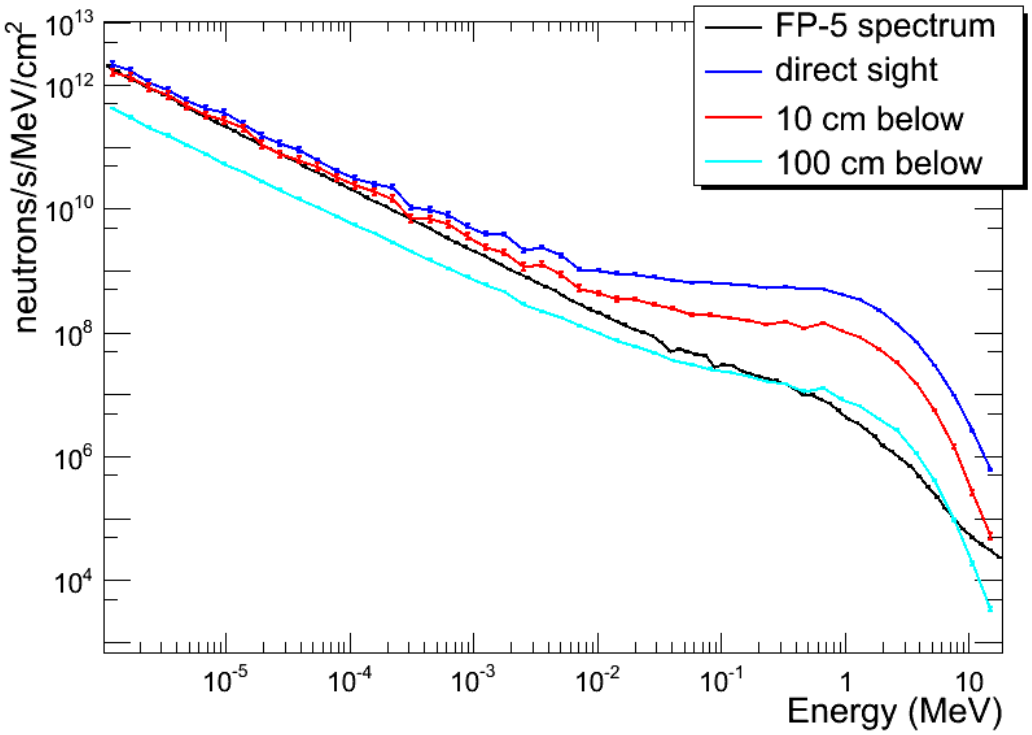

Figure 3: Neutron energy spectrum available at FP-5 (black) is compared to the neutron energy spectra expected at the production facility as shown in Figure 2.

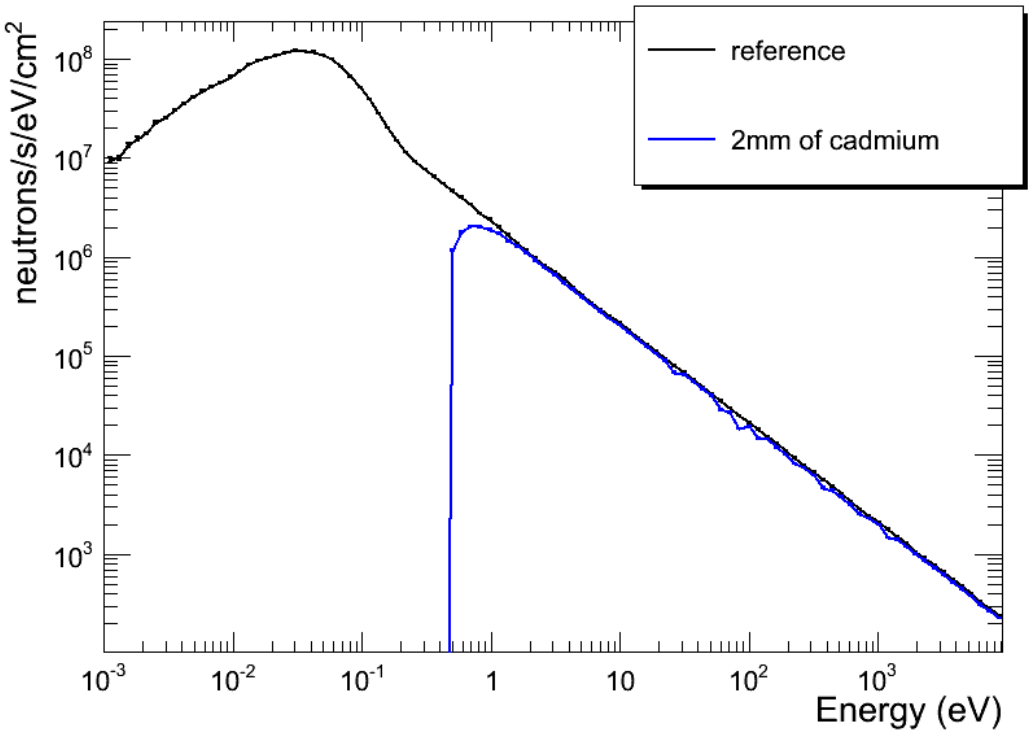

Figure 4: Neutron energy spectrum at FP-5 (black) compared to the spectrum attenuated by 2mm of cadmium.

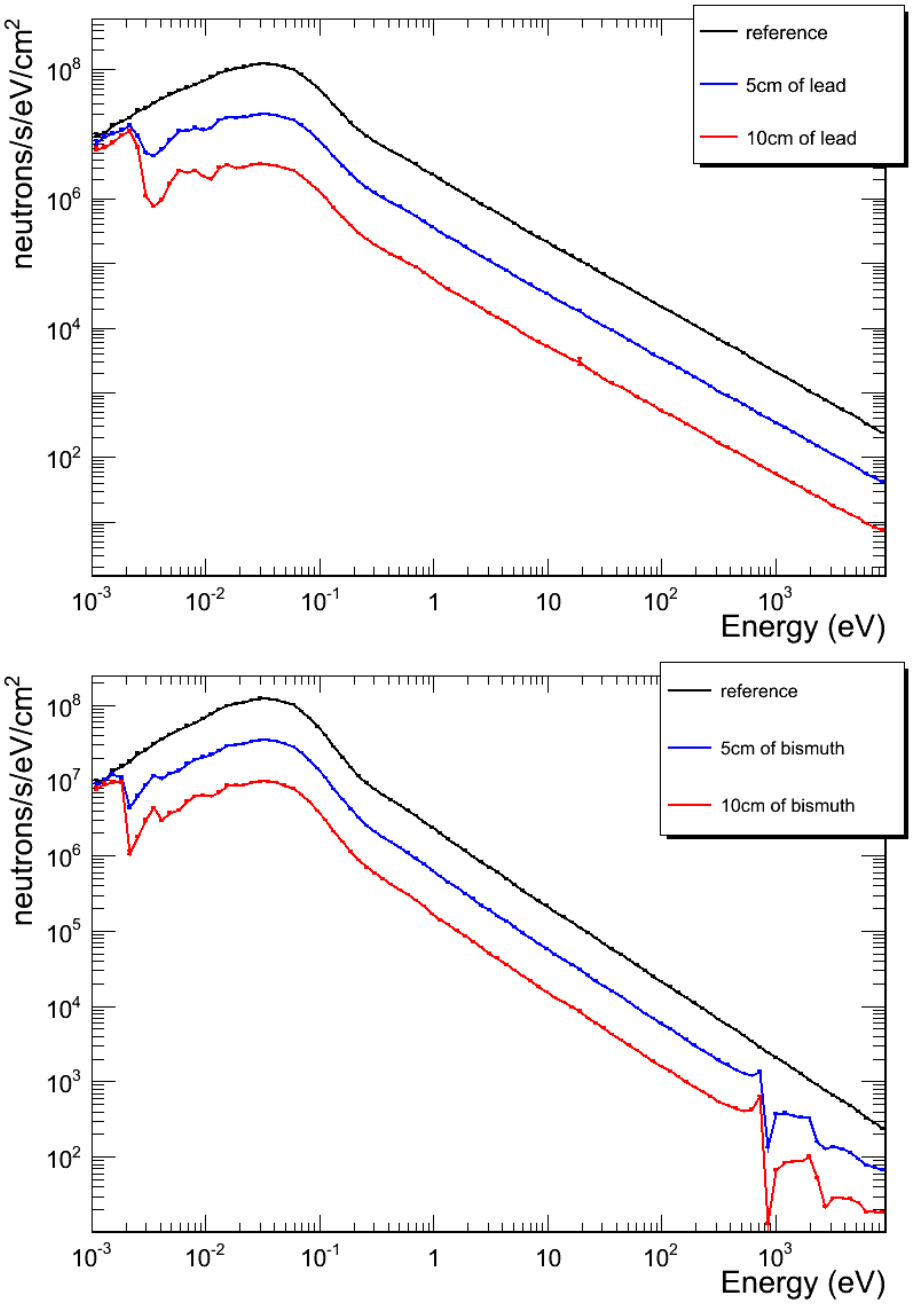

Figure 5: Neutron energy spectra at FP-5 (black) compared with attenuated spectra using lead and bismuth filters.

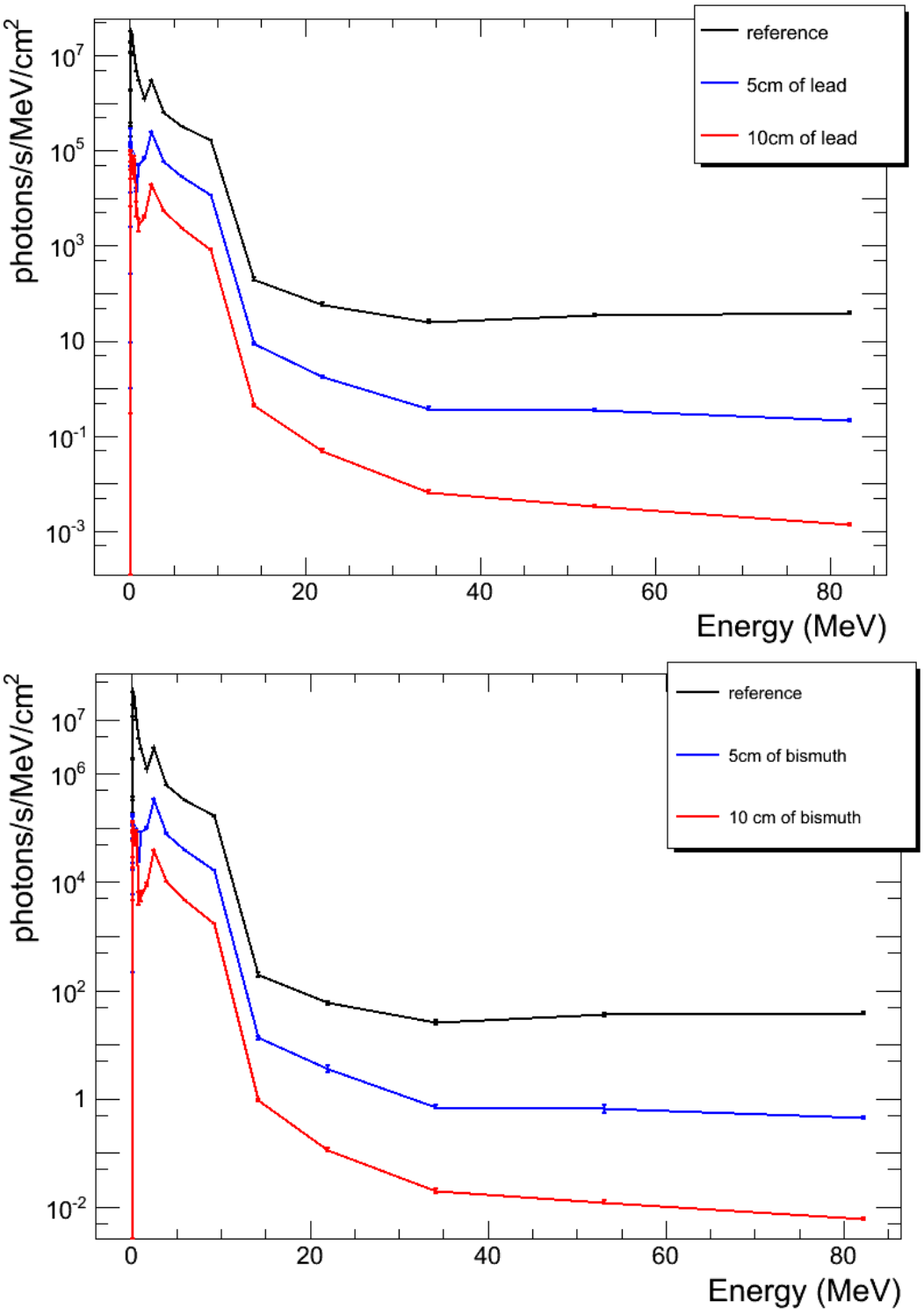

Figure 6: Gamma spectra at FP-5 (black) compared with attenuated gamma spectra by lead and bismuth filters.